Italian Journal of Agronomy
Rivista di Agronomia

An International Journal of Agroecosystem Management

July-September 2008 Vol. 3, No. 3 supplement

10th Congress of the European
Society for Agronomy
15-19 September 2008, Bologna, Italy

Multi-functional Agriculture
Agriculture as a Resource for Energy
and Environmental Preservation

edited by
Paola Rossi Pisa

The Official Journal of the
Italian Society of Agronomy

Italian Journal of Agronomy
Rivista di Agronomia

An International Journal of Agroecosystem Management

July-September 2008 Supplement Issue Vol. 3, No. 3 Suppl.

Contents

Management of Herbicide-Resistant Weed Beet: a Simulation Study

Yann Tricault[1], Mathilde Sester[2], Henri Darmency[1], Frédérique Angevin[3], Nathalie Colbach[1]

[1] UMR1210 Biologie et Gestion des Adventices, 21000 Dijon, France, colbach@dijon.inra.fr
[2] URP-SCRiD, CIRAD, Antsirabé, Madagascar, sester@cirad.mg
[3] UAR1240 Eco-innov, INRA, 78000 Thiverval-Grignon, France, Frederique.Angevin@jouy.inra.fr

In regions of sugar beet cultivation, weed beet infestations are responsible for economic losses. Weed beet belongs to the same species as the cropped plant, thus rendering herbicide control impossible in conventional sugar beet where costly practices such as manual weeding of bolters must be carried out instead. Genetically-modified herbicide-tolerant (GMHT) sugar beet varieties might provide an alternative in fields heavily infested with weed beet. However, accidental bolting of GMHT plants would result in pollen-mediated transgene flow towards weed beets. The objective of the present paper was to use a spatio-temporal simulation model for comparing 3 production systems with different cultural practices to evaluate the risk of herbicide-tolerant weed beet populations in a small agricultural region where GMHT and conventional sugar beet coexist.

Methodology

The GENESYS-Beet model was specifically designed to evaluate different cropping systems for their potential impact on weed beet infestation and transgene dispersal through time and space (Sester et al., 2007; 2008). Model inputs are (1) the regional field pattern, (2) the crop succession in each field, (3) the cultivation techniques used to manage each crop; (4) the genotype of the sugar beet varieties (e.g. GM vs. non-GM, male sterility genes); (5) daily climate and soil conditions. The model simulates the life-cycle of weed beet in every field as a function of abiotic constraints and cropping system variables (i.e. crop, tillage operations, herbicide treatment etc.). The model operates on a daily time step with life-stage densities and genotype proportions as state variables. Genotype proportions change when the herbicide associated to the transgene is applied (i.e. glyphosate in case of GM glyphosate-tolerant sugar beet) and during pollination. Gene flow is calculated from the pollen production of flowering plants in each field and the individual pollen dispersal function integrated over the whole region for every recipient field.

Table 1. Coexisting cropping systems in farm-type simulations

Cropping system	Sugar beet variety	% regional area	Ploughing	Manual bolter-weeding	Initial weed infestation (seed/m²)
A	GM	11	Yes	none	300
B	non GM	45	Yes	none	0
C	non GM	22	Yes	2	0
D	non GM	22	No	none	0

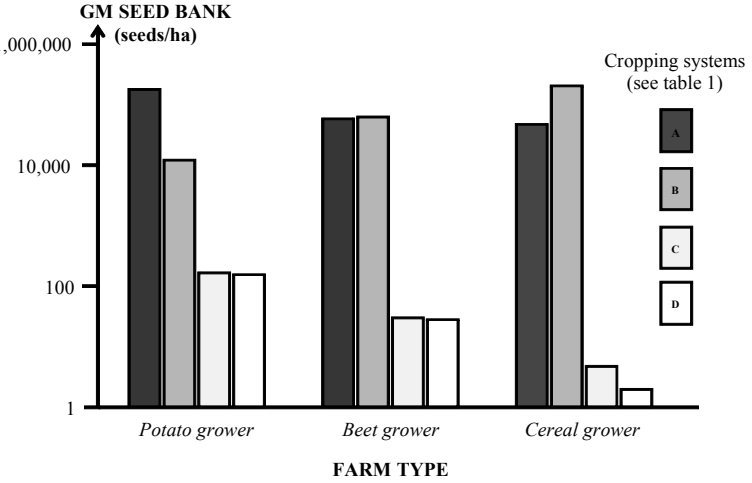
The GENESYS-Beet simulation model was used in a case study of a French sugar beet production region where 3 types of intensive production systems had been identified (Messéan et al., 2006): (1) "potato grower", with a sugar beet/potato/winter wheat/legume/winter wheat/potato/winter wheat rotation; (2) "beet grower", with a sugar beet/winter wheat/set aside/pea/winter wheat rotation; and (3) "cereal grower", with a sugar beet/winter wheat/pea/winter wheat rotation. The three production systems were successively simulated on a real 149 field map extracted from the studied region. At the onset of each simulation, the crops of the rotation were randomly distributed in the region. In addition, four cropping systems were randomly allocated to these fields (table 1). During the subsequent years,

crops depended on crop rotation. A field once grown with a GM variety was never cultivated with a non-GM variety and vice versa. Initial seed banks were empty except for GMHT fields where infestations of weed beets justify the adoption of herbicide-tolerant varieties. Simulations lasted 15 years with the GMHT weed seed bank as the output variable.

Results

Whatever the production system, all the fields were infested with GM seeds after 15 years. GM seed density was largest in GMHT sugar beet fields and ploughed conventional sugar beet fields without any manual weeding (Fig. 1). In unploughed and twice-weeded fields, GM seed density decreased considerably. No ploughing was even more efficient in the "cereal grower" system because the seeds were left to germinate on soil surface after sugar beet harvest, thus reducing seed survival in soil. This option is though only feasible if the following crop is a wheat where weed beet produces few seeds. Changing the management of the GM field also contributes to reducing GM seed bank in both GM and non-GM fields (Fig. 2).

Figure 1. Mean infestation of cropping systems with GMHT weed beet seeds after 15 years simulated with GENESYS-beet

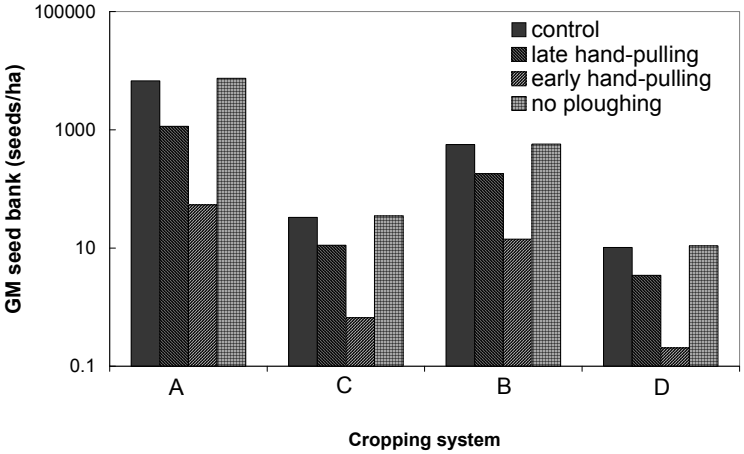


Conclusions

Our simulation results show that gene flow is inevitable, both in time and in space, but that it varies considerably with the cropping system. Similar results were obtained for oilseed rape.

Simulation models proved to be powerful tools for predicting the effect of alternative methods on gene flow to and from weed populations. But proposals still require economic feasibility studies.

Figure 2. Effect of the management of GM sugar beet on the GM seed bank meaned for the various cropping systems in the region after 15 years of GM cultivation in a traditional sugar-beet region.



References

Messéan A. et al. 2006. *New case studies on the coexistence of GM and non GM crops in European agriculture*. Technical Report Series of the Joint Research Center of the European Commission, EUR 22102 En, 112 p. http://www.jrc.es/home/pages/eur22102enfinal.pdf

Sester M. et al. 2007. Modelling the effects of cropping systems on the seed bank dynamics and emergence of weed beet. *Ecol. Model.*, 204:47–58.

Sester M. et al. 2008. GENESYS-BEET: A model of the effects of cropping systems on gene flow between sugar beet and weed beet. *Field Crop Res.*, 107:245-256.